

The University of Chicago

ECOLOGY OF THE MOSSES OF GRAND  
DE TOUR REGION OF ILLINOIS,  
WITH SPECIAL REFERENCE  
TO pH RELATIONS

A DISSERTATION SUBMITTED TO THE  
GRADUATE FACULTY IN CANDIDACY FOR  
THE DEGREE OF DOCTOR OF PHILOSOPHY

DEPARTMENT OF BOTANY

By  
CHARLES EDGAR MONTGOMERY

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# THE BOTANICAL GAZETTE

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ECOLOGY OF THE MOSSES OF GRAND DE TOUR  
REGION OF ILLINOIS, WITH SPECIAL  
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CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY 414

CHARLES E. MONTGOMERY

## Introduction

Work on soil reactions with respect to plant distribution has progressed greatly during the last few years. In a short review, WHERRY (31) states that although the first paper on soil reactions and natural plant distribution appeared in 1916, during the following decade more than 500 papers were published on this general subject. Among early workers, HEALD (11) found that the positive ion of weak acids and soil salts produced a toxic effect on seedlings. Following this lead, many theories concerning the causes of soil acidity were rapidly developed. HARRIS (9) reviewed these in 1914, and suggested that soil acidity was due to the fact that colloids adsorbed the negative ions from soil salts, leaving the positive ions to give the acid effect. WHERRY (26) described soil acids as both organic and inorganic, and indicated that colloids were indirectly effective.

The importance of total soil acidity soon gave way to the idea of H-ion concentration. GILLESPIE (5) discussed acid intensity, H-ion concentration, as a more potent factor in plant growth than total acidity. WHERRY (25, 27-30) has demonstrated the effect of the H-ion concentration upon many of the various groups of the higher plants. KURZ (14) showed the H-ion to be an important ecological factor in the different soils of the Chicago region. SALISBURY (19)



found that in old forest soils the top layer contained the higher H-ion concentration, which decreased in the lower layers and finally became alkaline. The alkaline materials of the top layers leach more readily than the acid and are therefore carried to the lower strata, leaving the acids above. Thus soils in different places show the variable reaction which is a basic factor in plant distribution. OLSON (17) found that as a rule the availability of some soil nutrients is not affected by the H-ion, and therefore the H-ion concentration itself is an important factor in plant groupings. Although WHERRY discovered that northern ferns generally prefer alkaline soils and southern ones prefer acid, STEAGALL (22) did not find that the ferns of Illinois showed these preferences. ROSEN (18) found a bacterial disease of foxtail sensitive to the H-ion concentration of the media.

Some experimenters have taken a slightly different angle of the problem. HARTWELL (10) noticed that the sap of flat turnips was more acid when grown in soils of a higher phosphorus content. TRUOG (24) states that alkaline substances of the soil caused plants to have higher alkaline contents. HABER (8), working with the tomato, found that the contents of the plant were affected proportionately to the acid or alkaline substances of the soil. The roots seemed to be most affected and the fruits least.

There is less literature on mosses in relation to the H-ion concentration. SKENE (20) found sphagnum sensitive to acids and bases both in substrata under natural conditions and in artificial cultures. KURZ (15), working on bogs, concluded that sphagnum and associated mosses were the cause of bog acidity. His conclusions were based on the fact that bogs where these mosses had not appeared were not acid but alkaline in reaction. AMANN (1) classified mosses as acid, subacid, neutral, and alkaline. He used the colorimetric method to test the soils, but there is no indication concerning the accuracy of his work. TAYLOR (23) studied the succession of mosses on various habitats in the Chicago region, and found an interesting correlation from this angle. DAVEY DE VIRVILLE (2) studied the relation of mosses to environment. He experimented on such ecological factors as sunlight, water, temperature, humidity, and soils, but did not touch upon the H-ion concentration.

The purpose of the investigation here reported was to discover the

H-ion concentration relationships between the mosses and their substrata in the region of Grand de Tour, Illinois, this vicinity offering a good variety of both mosses and habitats. In the beginning it was thought necessary to make tests only of the top centimeter of soil and the moss parts that lay upon the surface, but later it was found desirable to add readings of the soil 2-3 cm. deep. The first group of tests included such materials as moss bases, rhizoids, humus, and soil particles; the second group usually consisted of soil materials only, exclusive of moss parts and humus. In the original plan the intention was to gather data that would show to what extent if any the mosses affected the H-ion concentration of the soil. From evidence accumulated in this work, and from the work of KURZ (15), it seems likely that there is a contribution to the soil from the moss, but upon further study it was found that data gathered in this way could not be used in the solution of the problem. This part of the work had to be abandoned therefore, since it required a special method and a much longer time than the other parts of the program.

Finally the work resolved itself into the four following phases: (1) to discover the H-ion concentration of the mosses and the top soil to which they were attached; (2) to discover the H-ion concentration of the soil 2-3 cm. deep; (3) to see whether there was any correlation between (1) and (2); (4) to determine the H-ion range of some of the more common mosses of the region. The work on the last part was necessarily limited, because in making the tests the mosses were taken as they naturally occurred in the field, and no effort was made to get a certain large number of tests for any moss or group of mosses.

### Investigation

#### METHODS

With the exception of a few samples brought to the laboratory for checking, all tests were made in the field. The Morgan Soil set (16) was used throughout to test both the soils and moss materials. This is a colorimetric tester developed to an accuracy of 0.2 pH. It consisted of a porcelain block arranged in such a manner that when the soil was placed in part of a groove the indicator could be dropped into another place and allowed to run through it into a small pit. A color chart was then used to read the results. The indicators em-



ployed in this apparatus were phenol red, bromthymol blue, chlorphenol red, and bromcresol green. The complete range of the set was from 8.2 in phenol red to 3.8 in bromcresol green. At first tests were made of the top soil and the moss materials on the surface, but later tests of the soil 0.5-1 inch deep were also taken. If there was any doubt about the results in any case the test was repeated until a constancy was reached. In order to insure greater certainty, tests were made in the field, in the laboratory, and in both wet and dry conditions. Check tests were also made of the same plot at different times throughout the season. Moss samples were collected and brought to the laboratory for identification. The manuals of GROUT (6, 7) and DUNHAM (4) were used in this work.

All readings were taken in pH values because the color charts were marked in those figures. Thus the color chart for bromcresol green read 3.8-4.0-4.2-4.4-4.6-4.8-5.0-5.2-5.4-5.6, and the others followed the same scheme with a slight overlap on the indicator to each side. The pH values translated to units of H-ion concentration are as follows: the pH value of 3 equals the H-ion concentration of 0.001 (gm. H per liter), 4 is equal to 0.0001, 5 to 0.00001, 6 to 0.000001, 7 to 0.0000001 (the neutral point), and 8 to 0.00000001 (an alkaline reaction). Altogether there were a few over 1100 recorded tests. These are charted and listed in such a manner as to show the pH range of each area studied and the pH range of the different species found. In connection with the latter point, there were many species for which so few readings were taken that these can be considered only suggestive and not in any way conclusive.

#### GRAND DE TOUR REGION

The field covered in this survey included the Rock River bluffs and valleys in the vicinity of Grand de Tour, Illinois, some bluffs near Castle Rock and the Devil's Backbone, and the Illinois State Park known as The Pines. These places are all in the region called the Dixon quadrangle, as described by KNAPPEN (13) of the Illinois State Geological Survey. The region offered a wide variety of geological and ecological situations, such as gentle slopes, steep hillsides, valleys, open spaces, wooded spots, flat hill tops, and faces of hillsides in almost every direction. From a geological point of view the



region has exposures of St. Peter sandstone, Platteville limestone, and the Illinois glacial moraine. These materials are in various stages of erosion and are more or less mixed with humus from the plant cover.

St. Peter sandstone and the eroded sand from it form the basic soil for all the territory near Grand de Tour, Castle Rock, and the Devil's Backbone. This is found in open exposures and with different types of cover. It is in the realm of the oak-hickory climax and these woods occupy practically all the places studied. The north slopes and other protected places are usually coated with a layer of humus of varying degrees of thickness. These are in various stages of mesophytism and are covered with a wide variety of higher plants as well as mosses. Rock and sand outcrops are frequent, both on the tops of bluffs and hillsides. Such places are xerophytic and support a sparse vegetation.

The Pine Woods is a remnant of native white pine timber that has not only been able to maintain itself against the competition of other species, but is actually reseeding the parts that have been occupied by the oaks. The trees are rooted in a shallow layer of Illinois glacial till of varying depths. This overlies Platteville limestone which outcrops in the bluffs along Pine Creek. The creek has cut a deep valley through the park, forming steep bluffs that give a variety of places for the growth of plants. The pines begin at the top edge of the east bluff and extend eastward in varying widths throughout the length of the park. Oak-hickory woods occupy a large portion of the rest of the region. The east bluff is very mesophytic, and is covered with a thick growth of vegetation except in small sections of a vertical cliff. The west bluff is drier and has much more rock exposure. Cedars are prominent trees along this bluff.

This region lies in the cool temperate belt and has an average annual rainfall of 30-35 inches. The annual mean temperature is around 45° F. Climatic changes are often sudden and at times severe, but not so hard that the ordinary vegetation for this region ever fails to develop. DEFOREST (3) presented data on precipitation and temperature over a period of 62 years. He thought that during that period there was a slight drop in precipitation, but otherwise no noticeable change in climatic conditions.

## BABSON HOLLOW

In the woods along the river northwest from Grand de Tour, a small stream has cut a deep valley in the ridge parallel to the river edge. It runs in a westerly direction for a short distance, forming a typical mesophytic north-facing bluff about 50 feet high. This bluff is covered with oaks, walnuts, elms, and cherries. In the spring hepaticas, bloodroots, trilliums, claytonias, and many other common wood plants are abundant. Throughout the growing season parts of this slope are well matted with luxuriant growths of mesophytic mosses. Many of them scarcely check their growth through the drier months of summer, because of the very regular supply of water. Evaporation rates are always low because sun and wind have no chance to reach this secluded spot. In many places the mosses are in a pure stand while in others they represent a wide variety of mixtures.

At the top of the bluff, in an open place covering several square yards, are a few patches of *Polytrichum commune* and *Catharinea angustata*. These mosses are growing luxuriantly and are found in practically pure stands. Small bits of forest débris have settled among them, but not enough to interfere with their normal growth habits. This is the driest part of the whole plot, owing to the fact that the moisture supply is not so good as farther down the hillside and evaporation is more rapid. On this account growth ceases during the dry parts of the season.

Farther down the hillside different groups of mosses appear. Those that occur most commonly are *Catharinea undulata*, *Bartramia pomiformis*, and *Aulacomnium heterostichum*. In places they extend well to the bottom of the slope. *Bartramia* is especially abundant in the steeper shaded areas in both pure stands and mixtures. These mosses are rather hardy, and are prominent throughout the growing season. Other mosses that grow luxuriantly at different parts of the season are *Mnium cuspidatum*, *M. hornum*, *Hylocomium triquetrum*, *Thuidium recognitum*, *Eurhynchium serrulatum*, *Brachythecium oxycladon*, and *B. rutabulum*. *Eurhynchium* and *Brachythecium* occur all the way to the bed of the stream and may be found on soil and dead wood alike.

The underlying soil of this slope is St. Peter sandstone. In places it is covered with a layer of humus on which the mosses grow; in



others the moss mat is directly upon the sand and forms its own layer of humus. The source of water is not only from precipitation but from seepage and capillary movement. These give an ample supply which is well conserved for the heavy plant cover.

The H-ion concentration on this slope was characteristic of hill-sides in general. Near the top, in the more or less level beds of *Polytrichum* and *Catharinea angustata*, the moss tests ran between 5.0 and 6.0 and the soil 1 inch deep held between 4.0 and 5.0. Farther down the slope, in mixed beds of *Aulacomnium*, *Hylocomium*, *Bartramia*, and *Mnium cuspidatum*, the moss tests rose to a range from 6.4 to 7.6, while soil tests rose to 5.2. At the foot of the bluff and in the stream bed the moss tests reached 8.0 and 8.2, but the soil gave tests from 6.0 to 8.0. The entire range for the mosses on this slope

TABLE I  
BABSON HOLLOW; pH TESTS OF MOSSES AND TOP SOIL

| SPECIES                                | RANGE OF pH |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
|----------------------------------------|-------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|                                        | 4.4         | 4.6 | 4.8 | 5.0 | 5.2 | 5.4 | 5.6 | 5.8 | 6.0 | 6.2 | 6.4 | 6.6 | 6.8 | 7.0 | 7.2 | 7.4 | 7.6 | 7.8 | 8.0 | 8.2 |
| <i>Polytrichum commune</i> .....       |             | 3   | I   | 3   | 3   | 2   | I   | I   | 3   | 3   | I   | 2   |     | I   |     |     |     |     |     |     |
| <i>Catharinea angustata</i> .....      |             |     | I   |     | 2   |     | 2   | I   |     |     | I   | I   |     |     |     |     |     |     |     |     |
| <i>Catharinea undulata</i> .....       |             |     |     |     |     |     |     | I   |     |     | 3   | I   | I   | I   | 9   | 2   | 5   |     |     | I   |
| <i>Bartramia pomiformis</i> .....      |             |     |     |     |     |     | I   | I   |     |     |     | I   | 2   | 3   | 7   | 2   | 3   | I   |     | I   |
| <i>Aulacomnium heterostichum</i> ..... |             |     |     |     |     |     |     |     |     | I   | 3   |     |     |     | 3   | 5   | 3   |     |     | I   |
| <i>Mnium cuspidatum</i> .....          |             |     |     |     | I   | I   |     |     |     |     | I   | I   | I   | I   | 9   | 5   | 3   |     |     | I   |
| <i>Mnium stellare</i> .....            |             |     |     |     |     | 2   | I   |     |     |     |     |     | I   | I   |     | I   |     |     |     | I   |
| <i>Thuidium recognitum</i> .....       |             |     |     |     |     |     |     |     |     |     |     |     |     |     | 2   | I   | I   |     |     | I   |
| <i>Brachythecium oxycladon</i> .....   |             |     |     |     |     |     |     |     |     |     |     | I   | I   |     |     | 3   |     |     |     | I   |
| <i>Brachythecium rutabulum</i> .....   |             |     |     |     |     |     |     |     |     |     |     | I   | I   |     |     |     | I   |     |     | I   |
| <i>Amblystegium serpens</i> .....      |             |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     | I   | I   | 2   |
| <i>Eurhynchium hians</i> .....         |             |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     | I   |     |     |
| <i>Eurhynchium serrulatum</i> .....    |             |     |     |     |     |     |     |     |     |     |     |     |     |     | 2   |     | 2   | I   | I   | 4   |
| <i>Pylaisia schimperii</i> .....       |             |     |     |     | 2   |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |

was from 5.0 to 8.2; for the soils it was from 4.0 to 8.0 (table I). The acid mosses were confined to the top of the hillside on the higher acid soils. The alkaline groups were found from the middle to the base, and were distributed on both acid and alkaline soils. The pH correlation between the soil and mosses on this slope was close. The readings of the mosses generally varied 0.0–2.0 points above those of the soils on which they grew.

#### BABSON BLUFF

Rock River has cut a steep bluff for several rods along the south edge of the Babson wood. This bluff is an outcrop of St. Peter sand-

stone which is badly eroded into pockets, shelves, and crevices of many descriptions. In most places loose sand covers the rock, but at times the crumbly rock is bare. The top edge of this bluff is semi-xerophytic and for this reason was included in this study. Thin layers of humus have accumulated in pockets and other protected spots. Disintegration and erosion are rapidly changing the surface layers in many places. These features, together with the dry conditions, make an unfavorable situation for moss growth.

Vegetation along the edge of this bluff is not dense. Oaks and hickories are the dominant trees, with a fringe of junipers occupying the more exposed and difficult sites. Few of the herbaceous forms find a place to lodge. *Draba* sp. may be found along the shelves and paths, and *Viola pedata* is widely scattered over the slope above. On the more level spots *Amphicarpa monoica* attains a moderate growth in the late summer. There are no dense coverings of any kind and all plants reach only an average size. Mosses find this a difficult place in which to get a foothold. Some have been able to lodge on the narrow rock and sand ledges, and others have become well established on the stable surfaces under trees and in the more protected pockets. Although *Polytrichum commune* and *Catharinea angustata* have been able to spread over rather large patches, other mosses are found only in small clumps. None of the species have made the growth here that they have in more mesophytic places. Under the cedars and in more protected spots were well developed mats of *Brachythecium oxycladon*. This moss has a liking for neutral to alkaline soils, and on the sandy soil of this bluff maintains a range from pH 7.0 to 8.2. Sand shaken out of the rhizoids tests 7.0 and 7.2, but 1-inch deep tests range between 5.0 and 6.0. Other mosses occurring on this bank are *Catharinea undulata*, *Pohlia nutans*, *Mnium spinulosum*, *Bryum binum*, *B. argenteum*, *B. caespiticium*, *Encalypta ciliata*, and *Ceratodon purpureus*.

The pH readings of this region showed a wide variation and an unusual irregularity. *Polytrichum commune* ranged from 5.0 to 7.4, and *Catharinea angustata* varied from 6.0 to 8.0. Vertical slopes covered with *Mnium spinulosum*, *Encalypta ciliata*, or *Brachythecium oxycladon* were always neutral or alkaline, but if *Pohlia nutans* or *Dicranum scoparium* formed the moss cover the tests were regularly



acid. The entire range of this bluff for the mosses and top soils was 4.6-8.2; for the soils 1 inch deep it was 4.2-7.2. A complete list of the mosses found in this area with the range of their tests is given in table II.

TABLE II

| SPECIES                              | RANGE OF PH            |                          |
|--------------------------------------|------------------------|--------------------------|
|                                      | Moss and top soil test | Test of soil 1 inch deep |
| <i>Brachythecium oxycladon</i> ..... | 6.0-8.2                | 5.0-7.4                  |
| <i>Bryum argenteum</i> .....         | 7.6-8.2                | 8.0                      |
| <i>Bryum roseum</i> .....            | 7.6                    | 7.4                      |
| <i>Bryum caespitium</i> .....        | 5.4-7.6                | 6.2                      |
| <i>Bryum binum</i> .....             | 8.0                    | .....                    |
| <i>Mnium spinulosum</i> .....        | 6.4-7.2                | .....                    |
| <i>Catharinea angustata</i> .....    | 6.0-8.0                | 5.6-7.4                  |
| <i>Polytrichum commune</i> .....     | 5.2-7.4                | 5.6-6.2                  |
| <i>Barbula unguiculata</i> .....     | 7.4                    | .....                    |
| <i>Tortula ruralis</i> .....         | 7.8                    | .....                    |
| <i>Ceratodon purpureus</i> .....     | 4.6-7.6                | 5.2-5.6                  |
| <i>Encalypta ciliata</i> .....       | 7.6                    | .....                    |
| <i>Pohlia nutans</i> .....           | 5.2                    | .....                    |
| <i>Dicranum scoparium</i> .....      | 4.4-6.0                | 4.4                      |
| <i>Ditrichum pallidum</i> .....      | 7.4                    | 6.2                      |
| <i>Funaria hygrometrica</i> .....    | 7.4                    | 6.2                      |
| <i>Thelia lescurii</i> .....         | 7.0-7.2                | 7.2                      |

### BLACK HAWK BLUFFS

South and west of the county line bridge below Grand de Tour are three large moss plots that present very different situations. One is a dry hilltop with a mesophytic slope, another is a mesophytic shelf on the north side of a steep bluff, and the third is a wet hillside.

A few rods west of the bridge close by the river is a prominent outcrop of sandstone. The top is dry and open, with only a thin layer of sand covering a part of the rock. On the eastern edge are a few dwarf oaks, and on the north and west edges are some straggling specimens of *Pinus strobus* and *Betula lutea*. Huckleberries are able to find rooting in the large cracks of the rock, and *Draba* sp. and *Viola pedata* are the most common species of herbaceous plants. The south slope is gradual and not difficult of approach. Characteristic plants are *Ranunculus fascicularis*, *Antennaria alternifolia*, *Draba* sp., *Viola pedata*, *Synthyris bullii*, and a few hardy grasses. The east slope from the base almost to the top is mesophytic. *Quercus rubra*

and *Hamamelis virginiana* form the tree covering, and vigorous plants of *Arisaema triphyllum*, *Smilacina* sp., *Hepatica triloba*, and *Aralia nudicaulis* are the most common smaller forms.

At the foot of the east side the most widely distributed moss was *Mnium cuspidatum*. Other mosses that occurred in scattered patches were *Bryum caespiticium* and *Brachythecium oxycladon*. These mosses ranged from 7.4 to 8.2, and grew on a substratum that tested from 6.8 to 7.0. Near the middle of the hill were large mats of *Thuidium recognitum*, *Catharinea undulata*, and *Polytrichum commune*. These grew on thin layers of sand and over the edges of rock shelves. They ranged from 5.4 to 8.2. On the ledges and the summit of the bluff the species that occurred most frequently were *Polytrichum commune*, *P. piliferum*, *Catharinea angustata*, *Pohlia nutans*, and *Dicranella heteromalla*. The range was 4.2-7.8 while the substratum tested 4.4-7.2. Some noticeable irregularities occurred on this bluff. *P. piliferum*, which usually grew on highly acid soils, tested 7.2 on sandy soil with a range of 5.0-7.2. *C. angustata* tested 7.4 on soil of 7.0; *P. commune* and its soil both ran to 7.2. On the south slope were some large plots of *P. commune* mixed with a few specimens of *Thuidium recognitum*, *Bartramia pomiformis*, and *Brachythecium oxycladon*. These all tested from 7.2 to 7.8 and the soil ran 4.4-7.2. The tests of the soil usually ran about 7.2, but one spot was found in which the tests were 4.4.

These irregularities are probably caused by different water movements through the rocks and soil. In some places the water comes out as seepage from the layers above, giving a soil with an alkaline reaction. In others the water runs down through the soil, leaving acid conditions at the surface. A few rods south of this bluff is a steep hillside about 45 feet high covered with a thick carpet of mosses. Through the season water seeps down this hill, giving a good supply of moisture to the moss cover. Close around the moss bed are such plants as *Thalictrum dioicum*, *Smilacina* sp., *Hepatica triloba*, *Geranium maculatum*, and *Sanguinaria canadensis*. Trees grow near, so that direct sunlight does not fall upon the moss bank for any length of time during the day.

The base of the slope is well covered with *Catharinea undulata* intermixed with *Conocephalus* and *Bartramia pomiformis*. From 6 to 10 feet up *Catharinea* gives way to *Bartramia* and *Thuidium recog-*

*nitum*. Higher up *Mnium cuspidatum*, small clumps of *Polytrichum commune*, *Aulacomnium heterostichum*, *M. hornum* and *Anomodon attenuatus* complete the cover. These belts are adjusted rather closely to the moisture supply of the hill, with the drier part at the top.

Most of the pH tests of the mosses on this bank were alkaline. In one small plot of *Bartramia*, *Thuidium*, and *Polytrichum commune* the tests were 5.8 to 6.6, but all the others ranged from 7.0 to 7.8. Soil tests ranged from 6.0 to 7.0. The soil below these mosses was almost pure sand with a thin layer of humus formed by the mosses themselves.

A few rods farther south of this same bluff is another moss bank of a different type. It is a broad talus shelf with vertical cliffs above and below. The soil is pure sand held in place by moss beds and humus from the trees. It is a north slope completely shaded by oaks and the cliff above. The north edge is bordered by a number of scrubby pines.

The most interesting moss on this shelf was a luxuriant bed of *Climacium americanum*. A large patch and several small ones had become established near the base of the shelf. *Polytrichum commune* also grew well in the surrounding spaces. Other mosses found on the slope and cliff above were *Catharinea angustata*, *C. undulata*, *Pohlia nutans*, *Mnium cuspidatum*, *Bartramia pomiformis*, *Aulacomnium heterostichum*, *Thuidium recognitum*, and *Brachythecium oxycladon*. These showed their usual reactions when tested. *C. angustata* ran 5.2 on soil with the same test; *P. nutans* tested 4.6 on a sand wall of 4.2; *P. commune* ranged from 6.4 to 7.0 and the soil 1 inch deep tested from 5.4 to 7.0; *Climacium americanum* tested from 6.6 to 7.6, and the soil below ran from 5.2 to 7.0. Other mosses ranged 7.2–7.6 with soil tests varying from 4.8 to 6.8. Although the moss tests were rather regular the soil seemed to be more widely variant. The correlation between the mosses and soils was close in some cases but in others there was a wide difference (table III).

#### TREE MOSSES

Tree mosses in the Rock River region were not abundant nor vigorous. Three widely separated groups of trees were found to have somewhat representative species, and a brief survey of these was taken.



One wood, an old floodplain along the Black Hawk bluff, is a region of the mesophytic type. The common trees are *Ulmus americana*, *Celtis occidentalis*, and *Juglans nigra*. These are scattered so that there is plenty of sunlight for the grass cover underneath. The soil is chiefly a sand till washed in from the bluff above, mingled with silt and humus. A few partially decayed stumps and old logs made good substrata for mosses. On tree bases, old wood, and soil surrounding them are such species as *Anomodon minor*, *Amblystegiella adnata*, *Brachythecium oxycladon*, *B. rutabulum*, and *Mnium*

TABLE III

| SPECIES                                | RANGE OF PH |                             |
|----------------------------------------|-------------|-----------------------------|
|                                        | Moss tests  | Test of soil<br>1 inch deep |
| <i>Polytrichum commune</i> .....       | 5.0-7.4     | 4.4-7.4                     |
| <i>Polytrichum piliferum</i> .....     | 5.6-7.4     | 5.0-6.2                     |
| <i>Catharinea angustata</i> .....      | 5.4-7.4     | 5.4-6.0                     |
| <i>Catharinea undulata</i> .....       | 6.0-7.6     | 5.4-6.8                     |
| <i>Ceratodon purpureus</i> .....       | 7.4         | 6.4                         |
| <i>Dicranella heteromalla</i> .....    | 4.8         | .....                       |
| <i>Pohlia nutans</i> .....             | 4.2-4.6     | 4.2                         |
| <i>Aulacomnium heterostichum</i> ..... | 7.4-7.8     | 5.2-5.4                     |
| <i>Bartramia pomiformis</i> .....      | 7.2-7.8     | 5.4-6.0                     |
| <i>Bryum argenteum</i> .....           | 8.2         | .....                       |
| <i>Mnium cuspidatum</i> .....          | 7.6         | 5.4                         |
| <i>Mnium hornum</i> .....              | 7.4         | .....                       |
| <i>Thuidium recognitum</i> .....       | 5.8-7.4     | 4.8-7.4                     |
| <i>Anomodon attenuatus</i> .....       | 7.0-7.8     | 7.0-7.2                     |
| <i>Brachythecium oxycladon</i> .....   | 7.4-7.6     | 5.2-7.2                     |
| <i>Climacium americanum</i> .....      | 6.4-7.8     | 5.2-7.2                     |
| <i>Entodon cladorrhizans</i> .....     | 7.4         | 8.2                         |
| <i>Pylaisia schimperi</i> .....        | 7.4         | .....                       |

*cuspidatum*. The pH tests for mosses and their substrata were all alkaline, ranging 7.0-7.8. This is the usual condition for areas of this kind.

The uplands behind the floodplain have been cleared of underbrush and are occupied by pasture grasses. Oaks and hickories are left standing but do not interfere with growth of the grasses. The soil is sand mixed with a small amount of silt and humus. Mosses grow generally on the soil but some are found on the bases of the trees. Those occurring most frequently are *Anomodon attenuatus*, *Brachythecium oxycladon*, *Ceratodon purpureus*, and *Polytrichum commune*. The pH readings of the mosses ran 7.4 and 7.6 on soil that tested from 5.4 to 6.8.

About one mile to the southeast of the county-line bridge is a small open group of trees (oaks and hickories) supporting a few tree mosses. The soil is a gravelly till from the Illinoian ground moraine, sloping gently to the northwest and covered with a thin layer of leaf humus. Mosses find a footing on the soil, tree bases, old logs, and stumps. The most abundant species are *Anomodon attenuatus*, *Amblystegium serpens*, *A. kochii*, *A. adnatum*, *Entodon cladorrhizans*, and *Mnium cuspidatum*. The tests for the mosses, bark, and soil ranged 7.2-7.6 except in one case where the moss and bark went to 6.8.

The third wood studied for tree mosses was a portion of the eastern part of the pine-oak mixture at The Pines. Part of the work was in a thick growth of oaks with a heavy undercover, part in open timber, and the rest in a thick group of young pines. The soil was sand and gravelly till of the Illinoian ground moraine, covered generally with a layer of humus. In the oaks *Psedera quinquefolia*, *Celastrus scandens*, *Galium* sp., and many other forms hid the ground except in spots. Under the pines needles made such a thick coating of humus that few other plants could get a start. On tree bases, old logs, and stumps among the oaks were found *Mnium cuspidatum* and *Amblystegium serpens*. These tested from 7.0 to 8.2 on soils testing from 4.8 to 7.0. In the young pines the mosses were confined to the bases of trees and barren soils. The prevailing species were *Brachythecium rutabulum*, *Amblystegium serpens*, *Amblystegiella adnatum*, *Bryum roseum*, and *Catharinea undulata*. Tree mosses tested from 6.8 to 7.6 and soil mosses ran between 5.4 and 6.4. The pH of the soil under these pines varied from 4.0 to 7.0. A few small clumps of *Dicranella heteromalla* at the base of the larger pines ran to 4.4 on soil with a pH of 4.2. In all cases where a moss was found both on tree base and soil the soil specimen tested more acid. One case of *A. adnatum* on the bark of a pine showed a reading of 5.4, which is unusually low for tree mosses. In general these tests showed that tree mosses of this region were from neutral to the limit of the alkaline scale. Individual tests in other plots corroborated these data (table IV).

#### PINE WOODS

About 6 miles east of Polo, where the Burlington Railroad crosses Pine Creek, is the last important vestige of native white pines of north-

ern Illinois. At this point the creek has cut a valley 50-100 feet deep with vertical cliffs and steep slopes on the sides. The pines occupy a narrow strip along the east bluff for a distance of about 1 mile. Not only have the old pines been able to maintain themselves, but young trees are springing up among the oaks farther back, making good headway toward resetting other parts of the woods in pines. Mosses do not form a noticeable part of the pine wood flora; therefore the major effort of this study was spent along the bluffs of the valley.

TABLE IV

| SPECIES                               | RANGE OF PH |                             |
|---------------------------------------|-------------|-----------------------------|
|                                       | Moss test   | Test of soil<br>1 inch deep |
| <i>Catharinea crispa</i> .....        | 7.6         | 7.6                         |
| <i>Catharinea angustata</i> .....     | 5.4         |                             |
| <i>Catharinea undulata</i> .....      | 5.6-6.4     |                             |
| <i>Dicranella heteromalla</i> .....   | 4.2-7.0     | 4.4-6.8                     |
| <i>Physcomitrium turbinatum</i> ..... | 6.0         |                             |
| <i>Bryum roseum</i> .....             | 6.2-7.6     |                             |
| <i>Mnium cuspidatum</i> .....         | 7.4-8.2     | 7.4-8.2                     |
| <i>Anomodon minor</i> .....           | 7.6         |                             |
| <i>Anomodon rostratus</i> .....       | 7.4-7.6     |                             |
| <i>Anomodon attenuatus</i> .....      | 7.4-7.6     |                             |
| <i>Brachythecium oxycladon</i> .....  | 7.6         |                             |
| <i>Brachythecium rutabulum</i> .....  | 5.4-6.8     | 4.2-6.0                     |
| <i>Amblystegium adnatum</i> .....     | 7.2         | 7.2                         |
| <i>Amblystegium serpens</i> .....     | 7.2-8.2     | 5.2-8.2                     |
| <i>Amblystegiella adnata</i> .....    | 7.2         |                             |
| <i>Entodon cladorrhizans</i> .....    | 7.4         |                             |
| <i>Entodon seductrix</i> .....        | 7.0-7.2     |                             |

The bluffs are steep slopes covered with enough soil to support a good growth of oaks, elms, hop hornbeams, and cedars, with pines on the upper edge or they are vertical cliffs of solid limestone (Platteville) which carries a scant mixture of lichens, cliff brakes, mosses, and liverworts. The soil of this region is till from the Illinoian ground moraine. Along these bluffs it is a thin layer, but in many places it is covered with a mesophytic vegetation of *Claytonia virginica*, *Ranunculus septentrionalis*, *Arisaema triphyllum*, *Dentaria* sp., *Viola* sp., *Podophyllum peltatum*, and others of this type.

#### WEST BLUFF

The west bluff comprises a large area, including a part of the bluff of the main stream, cliffs, banks, and other plots along a small tribu-



tary stream that cuts through it from the northwest. The mosses of this area are practically all soil and rock species. On the whole the habitat is dry and thinly covered with vegetation.

The portion of the bluff along the main stream is a precipitous slope with a south face. The soil is thin except at the base, where it supports a growth of walnuts and elms. At the top limestone outcrops are numerous, and the most common tree found here is the cedar. Under the cedars a few poor specimens of *Aquilegia canadensis* have been able to get a footing on the ledges. Lower, *Aquilegia*, *Thalictrum dioicum*, *Rubus occidentalis*, and *Viola cucullata* are representative species. The slope is well shaded and the sunlight reaches only small spots for short periods each day. During the wet seasons mosses grow vigorously but in the summer they are usually dormant. The common mosses are *Grimmia apocarpa*, *Amblystegium serpens*, and *Mnium cuspidatum*. The substratum is soil, rock, shallow soil, and decaying wood. They form thin mats only and do not add much to the humus layer. Because these mosses are growing so close to the limestone surface, all pH tests were alkaline, ranging 7.6–8.2. The correlation was very close, since the soil layer is usually the top material to which the mosses were attached.

Several rods west of this bluff a small tributary flows in from the northwest. It has cut a deep valley in the limestone, leaving rocky cliffs and soil banks on which many mosses have become established. On the rocky cliffs the cedars are the only trees that can grow, but in the valley and on the lower slopes walnuts, elms, hackberries, and oaks are common. Grasses, *Aquilegia*, *Galium* sp., *Ranunculus fascicularis*, *Cynoglossum officinale*, *Viola cucullata*, and dwarfed strawberries make up the ground flora. The substrata are limestone and disintegrated rock with alluvium in the valley.

The mosses growing on the ledges and surfaces of the rock exposures were *Brachythecium oxycladon*, *B. rutabulum*, *Anomodon rostratus*, *Grimmia apocarpa*, *Barbula unguiculata*, and *Mnium cuspidatum*. On account of the dry and hard conditions all mosses showed thin mats of scanty growth. The pH readings were all highly alkaline, 8.0 and 8.2, owing to the presence of limestone. In the valley *Bryum caespitium* was the only moss that grew in abundance. It tested 8.0 as well as the soil. The soil mosses of the bluffs were *Bryum caespitium*, *Brachythecium oxycladon*, *B. rutabulum*, *Catha-*

*rinca undulata*, and *Ceratodon purpureus*. Some of these grew in dense mats in the open spaces between the trees. These mosses ranged between 6.8 and 8.2 with the median on the alkaline side (table V). One group of mosses consisting of *Thuidium recognitum*, *Polytrichum juniperinum*, and *Catharina angustata*, growing on a gravelly moraine tested from 5.2 to 5.8. The soil just below the mosses ran from 5.2 to 5.6. These mosses were well established and grew rapidly during the wet seasons. In this territory the mosses were closely confined to soils of their liking: the acid mosses held to acid soils and the alkaline species were found in their respective conditions.

TABLE V  
WEST BLUFF AT PINE WOODS; TESTS OF MOSSES AND TOP SOIL

| SPECIES                                          | RANGE OF pH |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
|--------------------------------------------------|-------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|                                                  | 5.0         | 5.2 | 5.4 | 5.6 | 5.8 | 6.0 | 6.2 | 6.4 | 6.6 | 6.8 | 7.0 | 7.2 | 7.4 | 7.6 | 7.8 | 8.0 | 8.2 |
| <i>Brachythecium oxycla-</i><br><i>don</i> ..... |             |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     | 5   |
| <i>Brachythecium ruta-</i><br><i>bulum</i> ..... |             |     |     |     |     |     |     |     |     |     |     |     | 1   |     |     |     |     |
| <i>Anomodon minor</i> .....                      |             |     |     |     |     |     |     |     |     |     |     |     | 1   |     |     |     |     |
| <i>Anomodon rostratus</i> .....                  |             |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     | 1   |
| <i>Amblystegium serpens</i> .....                |             |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     | 1   |
| <i>Grimmia apocarpa</i> .....                    |             |     |     |     |     |     |     |     |     |     |     |     | 1   |     |     |     | 2   |
| <i>Barbula unguiculata</i> .....                 |             |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     | 1   |
| <i>Bryum caespiticium</i> .....                  |             |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     | 1   |
| <i>Mnium cuspidatum</i> .....                    |             |     |     |     |     |     |     |     |     |     |     |     |     |     | 2   | 1   |     |
| <i>Polytrichum junipe-</i><br><i>rinum</i> ..... |             |     |     |     | 1   | 1   |     |     |     |     |     |     |     |     |     |     |     |
| <i>Catharina angustata</i> .....                 |             | 1   |     | 1   |     |     |     |     |     | 2   |     |     | 1   |     |     |     |     |
| <i>Ceratodon purpureus</i> .....                 |             |     | 1   |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| <i>Thuidium recognitum</i> .....                 |             |     |     | 2   | 1   |     |     |     |     |     |     |     |     |     |     |     |     |

#### EAST BLUFF

The east bluff has a long steep slope covered with a layer of glacial till and disintegrated rock. It has little rock exposure except in one small section where the limestone forms a vertical cliff. The whole bluff is mesophytic in character, even the rock cliff being moist enough in parts to support a growth of mosses and liverworts. The trees of this hillside consist of *Ulmus americana*, *Quercus alba*, *Q. rubra*, and *Ostrya virginiana*, with black walnut and red cedar at the base and the pines at the top. Since the ground vegetation is thick, the mosses find it difficult to become established. Small open

spaces, loose rocks, old logs, and tree bases are the spots on which they have been able to grow. The shade is dense and moss mats are usually small, thin, and not very vigorous.

The mosses growing in the edge of the pines at the top of the slope showed a different reaction from those farther down. They consisted of *Dicranella heteromalla* on soil at the base of pines, *Catharinea undulata*, *Ditrichum pallidum*, and a few specimens of *Mnium cuspidatum* and *Brachythecium rutabulum*. *Dicranella* was on soil that tested from 3.8 to 5.3, *Catharinea* ran between 6.2 and 7.4 on soil testing 5.3–6.0, and the other mosses ranged 6.0–6.8 while the soil varied around 5.8 and 6.0.

The reactions from a few yards below the top to the base were all from neutral to 8.0 in the alkaline scale. The mosses were chiefly pleurocarps consisting of *Brachythecium oxycladon*, *B. rutabulum*, *Amblystegium serpens*, *A. varium*, *Anomodon attenuatus*, *A. apiculatus*, *Pylaisia schimperii*, *Entodon cladorrhizans*, *Fissidens taxifolius*, and *Mnium cuspidatum*. *B. oxycladon*, *Mnium*, *Pylaisia*, *A. varium*, and *Entodon*, all growing on rotting wood and soil nearby, tested 5.6, 5.6, 5.2, and 6.8 respectively. All mosses found on soil or rock, including some of these, tested from 7.0 to 8.0. The soil tests were all within the upper one-half inch, and were included with the mosses. The acid soils at the top were characteristic of pinewoods, and the alkaline reactions on the lower slope were the usual type for a region of this kind. The most striking feature about this habitat so far as mosses are concerned was that the pleurocarp forms seemed to be better adapted to a shady, mesophytic, alkaline hillside such as this than the acrocarp forms.

A small section of the east bluff breaks into a vertical limestone cliff about 40 feet high. Three or four feet of glacial till cover the top edge, giving rooting for the large pines that grow close to the margin. Along a portion of the cliff there seems to be a seeping of water which runs down over the side, giving moisture to a thick coating of plants. These consist of *Conocephalus* (*Conocephalum conicum*), mosses, and such flowering plants as *Asarum canadense*, *Arisaema triphyllum*, *Hepatica triloba*, *Dicentra* sp., and *Mitella diphylla*.

The common mosses on the cliff and the talus at the foot are *Brachythecium oxycladon*, *Anomodon attenuatus*, *Mnium cuspidatum*,



and *Bryum roseum*. In places the mosses make a thick mat that covers the rock completely. The pH tests are all alkaline, 7.6 to 8.2 (table VI).

TABLE VI

| SPECIES                               | RANGE OF PH |                             |
|---------------------------------------|-------------|-----------------------------|
|                                       | Moss tests  | Test of soil<br>1 inch deep |
| <i>Catharinea undulata</i> .....      | 5.2-7.4     | 6.0-7.4                     |
| <i>Dicranella heteromalla</i> .....   | 3.8-4.6     | 3.8-4.6                     |
| <i>Ditrichum pallidum</i> .....       | 6.2-6.4     | .....                       |
| <i>Pottia truncata</i> .....          | 6.4         | .....                       |
| <i>Physcomitrium turbinatum</i> ..... | 6.8         | .....                       |
| <i>Mnium cuspidatum</i> .....         | 5.2-8.0     | 5.0-8.0                     |
| <i>Fissidens taxifolius</i> .....     | 7.4         | .....                       |
| <i>Brachythecium oxycladon</i> .....  | 5.6-8.0     | 5.6-7.4                     |
| <i>Brachythecium rutabulum</i> .....  | 7.0-8.0     | 7.0                         |
| <i>Anomodon apiculatus</i> .....      | 7.2         | .....                       |
| <i>Anomodon attenuatus</i> .....      | 7.2-8.0     | .....                       |
| <i>Amblystegium varium</i> .....      | 5.2-8.0     | .....                       |
| <i>Amblystegium serpens</i> .....     | 7.4-8.0     | .....                       |
| <i>Plagiothecium turfaceum</i> .....  | 7.2         | .....                       |
| <i>Entodon cladorrhizans</i> .....    | 0.8         | .....                       |

#### DEVIL'S BACKBONE

The Devil's Backbone is a prominent ridge of St. Peters sandstone about 2 miles south of Oregon. Back from the road a short distance the ridge is topped by Platteville limestone, but near the road this has eroded leaving the friable sandstone exposed. This is rough and broken, forming many shelves, crevices, and flats for the growth of plants. Such places are filled with sand and small amounts of humus left from plant débris. As is the case in most conditions of this type, the south slope is xerophytic and the north more nearly mesophytic. The talus on the south side is almost pure sand, but on the north it is covered with a layer of humus formed from fallen leaves and other forest materials. Above the talus on both sides the rock is precipitous. It was this part of the ridge that gave most of the data for this work. The common species able to maintain a foothold on these ledges are *Vaccinium vacillans*, *Amelanchier canadensis*, *Rumex acetosella*, and a few scattered grasses and sedges. On the north side, where there is more moisture and shade, *Polypodium vulgare* has found lodging in the crevices.

The mosses found on this hill are typical of this kind of place. *Polytrichum commune*, *P. piliferum*, *P. ohioense*, *Catharinea angus-*

*tata*, *Ceratodon purpureus*, *Dicranum scoparium*, *Dicranella heteromalla*, *Leucobryum glaucum*, *Pohlia nutans*, *Bryum caespitium*, and *Plagiothecium pulchellum* have become established in various spots over the surface. On the south side they have formed mats on the thin sand covering the ledges. Growth is stunted and only a few plants produce any fruiting stalks. At the top of the highest part of the ridge the soil is so thin and the exposure so complete that *P. piliferum* alone has been able to maintain itself to any noticeable extent. It is mixed with *Cladonia sylvatica* and *C. pyxidata*. The mosses on

TABLE VII

DEVIL'S BACKBONE AND SINNISSIPPI KNOB; TESTS OF MOSSES AND TOP SOIL

| SPECIES                               | RANGE OF pH |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
|---------------------------------------|-------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|                                       | 3.8         | 4.0 | 4.2 | 4.4 | 4.6 | 4.8 | 5.0 | 5.2 | 5.4 | 5.6 | 5.8 | 6.0 | 6.2 | 6.4 | 6.6 | 6.8 | 7.0 |
| <i>Polytrichum commune</i> .....      |             |     | I   | 4   | 2   | I   |     | 2   | I   | 2   | I   |     | I   | I   |     |     |     |
| <i>Polytrichum piliferum</i> .....    | I           |     | 2   | I   | 2   | I   | I   | I   | 2   | I   | I   |     |     |     |     |     |     |
| <i>Polytrichum ohioense</i> .....     |             | I   | I   |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| <i>Catharinea angustata</i> .....     |             |     |     |     | I   |     | I   |     | 3   | 3   |     |     |     |     |     |     |     |
| <i>Hedwigia albicans</i> .....        |             |     |     |     |     |     |     | 2   | I   |     |     |     | I   |     |     |     |     |
| <i>Ceratodon purpureus</i> .....      |             |     |     |     | 2   |     |     | I   | 2   |     |     |     |     | I   |     | I   | I   |
| <i>Dicranum scoparium</i> .....       | I           |     | 2   |     | 3   |     |     | 4   | I   | I   |     |     |     |     |     |     |     |
| <i>Ditrichum pallidum</i> .....       |             |     |     |     |     |     |     |     | I   |     |     |     |     |     |     |     |     |
| <i>Dicranella heteromalla</i> .....   | I           |     | 2   |     |     | I   |     | 3   | I   |     |     |     |     |     |     |     |     |
| <i>Leucobryum glaucum</i> .....       |             |     |     |     | I   | 3   |     |     |     |     |     |     |     |     |     |     |     |
| <i>Bryum caespitium</i> .....         |             |     | 2   |     |     |     |     |     | I   |     |     |     |     |     | I   |     |     |
| <i>Pohlia nutans</i> .....            | I           | I   | I   | I   | 5   |     | I   |     | 2   | 2   | I   |     |     |     |     |     |     |
| <i>Brachythecium rutabulum</i> .....  |             |     |     |     |     |     |     |     |     |     |     |     |     |     | I   |     |     |
| <i>Calliergon schreberi</i> .....     |             |     |     |     |     |     |     |     |     | I   |     |     |     |     |     |     |     |
| <i>Plagiothecium pulchellum</i> ..... |             | I   | 2   |     | I   |     |     |     |     |     |     |     |     |     |     |     |     |

the north side are not any more numerous, but make a much more prolific growth than on other parts of the hill. They grow on ledges, in crevices, and on the vertical rock face without difficulty, and are able to fruit in season.

This hill was highly acid in all the places tested. The pH range for the mosses and the soil in their rhizoids was 3.8-5.4 (table VII). Readings of the sand not deeper than 1 inch ran 3.8-4.6. The adjustment of the moss flora on this rock was the closest found anywhere in the region. *Polytrichum ohioense* was found on the moist north slope. The other two species of *Polytrichum* were in drier places but in the same type of soil. *Plagiothecium pulchellum* grew well on the

acid rock in rather dry but shady spots. *Dicranella heteromalla*, *Dicranum scoparium*, and *Pohlia nutans* thrived on all sides but did best on the wetter face. Although the amount of water had much to do with the growth of the moss mat, it did not make much difference in the H-ion concentration of either the soils or the mosses.

#### SINNISSIPPI KNOBS

A few rods south of the Devil's Backbone are two prominent Knobs. These are of St. Peter sandstone with low and well rounded tops. The slopes are gentle and support a moderate mesophytic plant cover. There are some barren rock exposures at the top, but the surface is broad and is covered with a thin layer of soil. Trees of the oak-hickory climax reach almost to the tops and give a medium shade on the east, north, and west sides. The best growth of mosses is on these three sides and the tops.

The bases of the east slopes of these two hills were much alike and had similar moss floras. The common mosses were *Ceratodon purpureus*, *Funaria hygrometrica*, *Bryum caespitium*, *Brachythecium rutabulum*, and *Amblystegiella adnata*. The mosses gave pH readings from 5.2 to 6.6 while the soil tests ran 4.8-5.6. These forms were growing well but did not develop into large thick mats. From half way up to the tops the moss species changed noticeably. Approaching the summits *Dicranella heteromalla*, *Bryum caespitium*, *Catharina angustata*, *Polytrichum commune*, *Pohlia nutans*, *Hedwigia albicans*, *Entodon seductrix*, and *Calliergon schreberi* appeared in well developed plots. *Dicranum scoparium* and *P. piliferum* occupied the higher places at the top. The pH tests of this group showed higher acid conditions than near the bases. The range for the moss materials was between 4.2 and 6.4 and the soil ran 4.2-5.6. In one case *Entodon seductrix*, growing near the top on rock, tested 6.8 for both the moss and thin layer of soil, but in most of the tests the pH stood about 5.2 and 5.4.

While the H ion concentration at the bases of the slope approached close to the neutral point, the upper parts of the hills showed the usual acid reactions for the sand exposures of the region. Again it may be noted that it made little difference regarding the moisture content of the substratum. Tests from moss plots on bare rock ran



much like those on the sand and humus soil which held more moisture.

In the surrounding woods were many excellent moss plots. Growing on the rocks and sand were *Polytrichum commune*, *P. piliferum*, *Hedwigia albicans*, *Dicranum scoparium*, *Ditrichum pallidum*, *Ceratodon purpureus*, and a few other scattered species. Although the plots were not large, growth was good and sporophytes were usually present. The pH range of the moss material was 5.2–6.8 and that of the soil 4.4–5.6. A few tree mosses gave a different reaction. They consisted of *Pylaisia schimperi*, *Brachythecium rutabulum*, *Amblystegiella adnata*, and *Anomodon attenuatus*. Tests of this group ran between 5.6 and 7.4 with the majority between 6.8 and 7.2. Although these were miscellaneous spots, the mosses occupying the different places were very true to type.

#### CASTLE ROCK AND VICINITY

No other spot along the Black Hawk trail is more widely known and more frequently visited than the sandstone prominence about 3 miles south of Oregon called Castle Rock. It stands 100 feet or more above the river. The top is hard sandstone but the base on three sides is well built up from eroded sand which gives a good place for the growth of plants. The north side, being better shaded, supports some excellent beds of mosses. Characteristic plants of this slope are *Quercus alba*, *Q. ellipsoidalis*, *Amelanchier canadensis*, *Rubus allegheniensis*, *Vaccinium vacillans*, *Maianthemum canadense*, *Polygonatum biflorum*, *Smilacina racemosa*, and *Dicentra cucullaria*.

In the vicinity of Castle Rock are five other hillsides upon which are found excellent moss plots. Three of them are south slopes and the other two are north. All are St. Peter sandstone outcrops, usually supporting the mesophytic vegetation commonly found in the oak woods of this region. The substrata are of sandy soil, generally mixed with humus of various depths, none exceeding 4 inches, and rock faces that are kept moist throughout most of the year by precipitation and seepage. All these places are well shaded during the growing season, either on account of the position of the hillside or by trees.

Mosses grew in great profusion in these several places. They occu-

pied rock ledges, shallow caves, vertical faces, moist and arid spots, and places of both shade and open sunlight. In many places they grew in such dense mats that they not only added humus to the soil but prevented erosion of the loose sand. The heaviest mats were of *Polytrichum commune*, *P. piliferum*, *Dicranum scoparium*, *Dicranella heteromalla*, *Catharina angustata*, and *Calliergon schreberi*. In one place dead stems of *P. commune* extended more than 4 inches below the present level of the soil.

The mosses commonly found in this region are *Polytrichum commune*, *P. piliferum*, *Catharina angustata*, *Dicranum scoparium*, *Ditrichum pallidum*, *Dicranella heteromalla*, *Pohlia nutans*, *Funaria hygrometrica*, *Georgia pellucida*, *Ceratodon purpureus*, *Amblystegiella adnata*, *Calliergon schreberi*, *Brachythecium rutabulum*, and *Mnium cuspidatum*. Others occurred less frequently and seemed to be out of their range, such as *Brachythecium oxycladon*, *Plagiothecium denticulatum*, *Anomodon attenuatus*, and *Bartramia pomiformis*. Even though the latter group was out of its natural habitat, the individual species maintained their usual reactions about the neutral point, 6.6–7.4. *P. commune* growing among these mosses also tested as high as 6.8.

The H-ion concentration of this whole group of moss habitats is consistently high, scarcely going below 5.6 in the soil tests at the 1 inch level. In a few cases the top soil with humus and rhizoids ran to 6.4–6.6. The pH readings for the mosses correlated closely with those of the soils, ranging from 4.2 to 6.8 (table VIII). This correlation, together with the fact that the mosses grew so vigorously and produced sporophytes, indicated strongly that so far as the moss flora of this region was concerned it was a climax situation. The few neutral and alkaline species found were not showing the vigor and growth noticed in the other group. Their present condition suggested that they were probably remnants of an earlier moss flora of a different type.

#### SPECIES RANGE

The preceding observations give some idea of the H-ion concentration of each of the different areas tested, but in no case were enough tests made of the individual species to be more than suggestive. The number of tests ranged from one for several species to

96 for *Polytrichum commune*. There was no special effort to favor any particular moss, but the number of tests indicates in a good measure the relative importance of each one in the Grand de Tour region. In this respect *P. commune* stands far above the rest, having occurred in every area where there was a sandy soil base.

Consideration of the species range requires a great number of pH readings to reach any definite conclusions. Since this work was not directed specially toward that problem, but to a more general pur-

TABLE VIII

| SPECIES                                 | RANGE OF pH |                             |
|-----------------------------------------|-------------|-----------------------------|
|                                         | Moss tests  | Tests of soil below surface |
| <i>Polytrichum commune</i> .....        | 4.2-6.8     | 3.8-6.4                     |
| <i>Polytrichum piliferum</i> .....      | 4.4-6.8     | 4.2-6.8                     |
| <i>Catharinea undulata</i> .....        | 6.6         | 4.6                         |
| <i>Catharinea angustata</i> .....       | 4.4-6.2     | 3.8-5.4                     |
| <i>Georgia pellucida</i> .....          | 3.8-5.6     | 4.2-5.2                     |
| <i>Ceratodon purpureus</i> .....        | 4.8-6.4     | 4.4-5.8                     |
| <i>Dicranum scoparium</i> .....         | 4.0-5.6     | 4.0-6.4                     |
| <i>Ditrichum pallidum</i> .....         | 4.4         | 4.2                         |
| <i>Ditrichum tortile</i> .....          | 4.2         | .....                       |
| <i>Dicranella heteromalla</i> .....     | 4.4-7.0     | 3.8-6.0                     |
| <i>Pohlia nutans</i> .....              | 3.8-5.2     | 3.8-5.0                     |
| <i>Bryum caespitium</i> .....           | 4.8-6.8     | 5.4                         |
| <i>Mnium cuspidatum</i> .....           | 5.0-5.8     | .....                       |
| <i>Anomodon rostratus</i> .....         | 7.4         | 4.6                         |
| <i>Anomodon attenuatus</i> .....        | 6.2-7.0     | 5.2                         |
| <i>Brachythecium oxycladon</i> .....    | 6.4-6.8     | 4.4-5.2                     |
| <i>Brachythecium rutabulum</i> .....    | 7.0-7.2     | 5.2                         |
| <i>Amblystegiella adnata</i> .....      | 4.6-4.8     | .....                       |
| <i>Calliergon schreberi</i> .....       | 4.8-7.2     | 4.2-7.4                     |
| <i>Plagiothecium denticulatum</i> ..... | 4.8-5.8     | 4.2-5.4                     |
| <i>Hypnum haldanianum</i> .....         | 4.0-5.0     | 4.0                         |

pose, it is not expected that these figures should be considered final. Altogether there were 62 species of mosses found in this territory, belonging to 14 different families. Of these only 20 species showed tests of 10 or more, while 9 had 20 or more. A few of the outstanding ones will be mentioned merely for the purpose of emphasis.

All species of *Polytrichum* were acid and grew on acid soils. *Catharinea undulata* preferred soil from neutral to low acid, while the moss and top soil materials ranged from 5.4 to 8.2 with the majority of tests about neutral. *C. angustata* on the other hand was found in more acid soil and had a higher H-ion concentration than its related



species. *Pohlia nutans*, *Dicranum scoparium*, and *Dicranella heteromalla* also grew well in acid soils. Two pleurocarps showed a preference for acid soils, *Calliergon schreberi* and *Hypnum haldanianum*. The outstanding mosses that ran from about the neutral point to the alkaline end of the scale were *Mnium cuspidatum*, *Bartramia pomiformis*, *Aulacomnium heterostichum*, *Brachythecium* spp., *Anomodon* spp., *Thuidium recognitum*, and *Climacium americanum*. *Ceratodon*

TABLE IX  
RANGE OF PH OF MORE COMMON SPECIES FOUND IN REGION

| SPECIES                                | RANGE OF PH |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |  |  |  |  |  |
|----------------------------------------|-------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--|--|--|--|--|
|                                        | 3.8         | 4.0 | 4.2 | 4.4 | 4.6 | 4.8 | 5.0 | 5.2 | 5.4 | 5.6 | 5.8 | 6.0 | 6.2 | 6.4 | 6.6 | 6.8 | 7.0 | 7.2 | 7.4 | 7.6 | 7.8 | 8.0 | 8.2 |  |  |  |  |  |
| <i>Polytrichum commune</i> .....       |             |     | I   | 2   | 5   | 3   | 10  | 14  | 8   | 11  | 3   | 4   | 5   | 5   | 6   | 11  | 1   | 1   | 3   | 1   |     |     |     |  |  |  |  |  |
| <i>Polytrichum piliferum</i> .....     |             |     | 2   |     | 3   | 2   | 2   | 6   | 7   | 0   | 1   |     | 2   |     | 3   |     | 1   |     |     |     |     |     |     |  |  |  |  |  |
| <i>Catharinea undulata</i> .....       |             | I   |     |     |     |     |     |     |     | I   | I   |     | 2   | 3   | 5   | 5   | 2   | 6   | 5   | 4   | 5   |     |     |  |  |  |  |  |
| <i>Catharinea angustata</i> .....      |             |     |     |     | I   | I   | 4   | 0   | 0   | 0   |     | 3   | 2   | 3   | I   | 2   |     |     | 1   | I   |     |     |     |  |  |  |  |  |
| <i>Dicranum scoparium</i> .....        | I           | I   | 2   | 1   | 2   |     | I   | 10  | 4   | 5   |     | I   |     |     | I   |     |     |     |     |     |     |     |     |  |  |  |  |  |
| <i>Dicranella heteromalla</i> .....    | 2           |     | 2   | 4   | I   | I   | 3   | 3   | 1   |     |     |     |     |     |     |     | I   |     |     |     |     |     |     |  |  |  |  |  |
| <i>Pohlia nutans</i> .....             | I           | I   | 3   | 3   | 6   | 3   | 2   | 11  | 4   | 4   | 2   | 1   |     |     | I   |     |     |     |     |     |     |     |     |  |  |  |  |  |
| <i>Ceratodon purpureus</i> .....       |             |     |     |     | 4   | I   |     | I   | 3   |     |     |     | 2   | I   | I   | I   |     |     | 3   | I   |     |     |     |  |  |  |  |  |
| <i>Georgia pellicida</i> .....         | I           |     | 2   | I   | I   | 2   | 2   | 2   | 2   |     |     |     |     |     |     |     |     |     |     |     |     |     |     |  |  |  |  |  |
| <i>Bryum caespitium</i> .....          |             |     | 2   |     | 2   | I   | I   | 2   |     |     |     |     |     |     |     | I   |     | 2   |     |     | I   |     |     |  |  |  |  |  |
| <i>Bartramia pomiformis</i> .....      |             |     |     |     |     |     |     | I   |     |     |     | 2   |     |     | I   |     | I   | 5   | 10  | 3   | 3   | 4   |     |  |  |  |  |  |
| <i>Aulacomnium heterostichum</i> ..... |             |     |     |     |     |     |     |     |     |     |     |     |     |     |     | I   |     | 2   | I   | 5   | 3   | 1   |     |  |  |  |  |  |
| <i>Mnium cuspidatum</i> .....          |             |     |     |     |     | I   | I   | 2   | I   | I   | 2   | I   |     | 2   | 2   | I   | I   | 9   | 9   | 4   | 3   | 2   | 2   |  |  |  |  |  |
| <i>Thuidium recognitum</i> .....       |             |     |     |     |     |     |     | I   |     |     | 2   | 2   | 2   |     | 3   | I   |     | 2   | 2   | I   |     |     |     |  |  |  |  |  |
| <i>Brachythecium oxycodon</i> .....    |             |     |     |     | I   |     |     |     |     |     |     |     | I   |     |     |     |     | I   | I   |     | 2   | 2   |     |  |  |  |  |  |
| <i>Brachythecium rutabulum</i> .....   |             |     |     |     | I   |     |     |     |     | I   | 1   | 1   |     | 1   | 4   | I   | 2   | I   | 2   | 4   | I   | 3   | 3   |  |  |  |  |  |
| <i>Calliergon schreberi</i> .....      |             |     |     |     |     |     | I   |     |     |     | 2   | 1   | 1   |     |     |     | 3   |     |     |     |     |     |     |  |  |  |  |  |

*purpureus* although found on acid soils had a rather well distributed range, 4.6-7.6.

Another significant fact shown by these data was that the soil on which the mosses grew usually tested a little higher acid than the moss materials and top soils. The soils were not more constant at the 0.5 inch depth than the mosses, but seemed to vary rather closely with them. These two points seemed to be suggested, namely, the more acid the moss the more acid can be the soil on which it may grow; and the more alkaline the moss the less acid the soil which it will tolerate. Table IX gives the pH range for the mosses

that occurred most frequently. A list of mosses occurring in the region so few times that they were not charted is given in table X.

TABLE X

| Moss                                | NUM-<br>BER<br>OF<br>TESTS | pH<br>RANGE | Moss                                | NUM-<br>BER<br>OF<br>TESTS | pH<br>RANGE |
|-------------------------------------|----------------------------|-------------|-------------------------------------|----------------------------|-------------|
| <i>Polytrichum ohioense</i> .....   | 3                          | 4.0-4.2     | <i>Anomodon minor</i> .....         | 1                          | 7.4         |
| <i>Polytrichum juniperinum</i> .... | 2                          | 5.6-5.8     | <i>Anomodon attenuatus</i> .....    | 12                         | 6.8-8.2     |
| <i>Catharinaea crispa</i> .....     | 1                          | 7.6         | <i>Anomodon rostratus</i> .....     | 5                          | 7.4-7.8     |
| <i>Fissidens taxifolius</i> .....   | 1                          | 7.4         | <i>Anomodon apiculatus</i> .....    | 1                          | 7.0         |
| <i>Fissidens adiantoides</i> .....  | 1                          | 7.0         | <i>Thelia lescurii</i> .....        | 2                          | 7.0-7.2     |
| <i>Ditrichum pallidum</i> .....     | 5                          | 4.8-6.4     | <i>Leskia gracilescens</i> .....    | 1                          | 7.6         |
| <i>Dicranum flagellare</i> .....    | 1                          | 4.6         | <i>Hylacomium triquetrum</i> ....   | 3                          | 6.6-7.2     |
| <i>Dicranum pallidum</i> .....      | 3                          | 5.0-5.2     | <i>Eurhynchium hians</i> .....      | 1                          | 7.6         |
| <i>Leucobryum glaucum</i> .....     | 4                          | 4.6-5.0     | <i>Eurhynchium serrulatum</i> ....  | 12                         | 7.0-8.2     |
| <i>Grimmia apocarpa</i> .....       | 4                          | 7.4-8.2     | <i>Brachythecium salebrosum</i> ..  | 3                          | 5.4-7.0     |
| <i>Hedwigia albicans</i> .....      | 5                          | 5.4-6.2     | <i>Amblystegium serpens</i> .....   | 10                         | 5.8-8.2     |
| <i>Tortula ruralis</i> .....        | 1                          | 7.8         | <i>Amblystegium varium</i> .....    | 12                         | 5.2-8.2     |
| <i>Barbula unguiculata</i> .....    | 2                          | 7.4-8.2     | <i>Amblystegium adnatum</i> ....    | 2                          | 7.2         |
| <i>Encalypta ciliata</i> .....      | 2                          | 7.6         | <i>Climacium americanum</i> .....   | 8                          | 6.6-7.8     |
| <i>Funaria hygrometrica</i> .....   | 2                          | 5.2-7.6     | <i>Hypnum haldanianum</i> .....     | 5                          | 3.8-5.4     |
| <i>Physcomitrium turbinatum</i> ..  | 2                          | 6.0-6.6     | <i>Plagiothecium pulchellum</i> ..  | 4                          | 4.0-6.0     |
| <i>Timmia cucullata</i> .....       | 4                          | 8.2         | <i>Plagiothecium turfaceum</i> .... | 3                          | 7.4         |
| <i>Bryum argenteum</i> .....        | 4                          | 6.2-8.2     | <i>Plagiothecium denticulatum</i>   | 4                          | 4.8-6.8     |
| <i>Bryum roseum</i> .....           | 3                          | 6.2-7.6     | <i>Amblystegiella adnata</i> .....  | 7                          | 4.6-7.2     |
| <i>Bryum binum</i> .....            | 3                          | 4.8-5.0     | <i>Entodon seductrix</i> .....      | 7                          | 6.8-7.6     |
| <i>Mnium hornum</i> .....           | 2                          | 7.0-7.4     | <i>Entodon cladorrhizans</i> .....  | 3                          | 6.8-7.4     |
| <i>Mnium stellare</i> .....         | 6                          | 5.8-8.2     | <i>Pylaisia schimperi</i> .....     | 5                          | 5.6-7.4     |
| <i>Mnium spinulosum</i> .....       | 2                          | 6.4-7.0     |                                     |                            |             |

### Summary and conclusions

1. Mosses seem to have an H-ion range within which they can grow. Within these limits the optimum is usually near the median.
2. Mosses on the sandy soils of this region are generally the acid-loving types, although some are alkaline.
3. On the hilltops and on sandstone the mosses are acid-loving; at the bases of the hills and on the sides they may be alkaline.
4. Tree mosses run from neutral to alkaline; those on old wood are acid.
5. Mosses on limestone and the thin soils overlying it are alkaline; those on the banks of the small streams are also alkaline.
6. Most acid-loving mosses are acrocarps; most alkaline mosses are pleurocarps.
7. There is a close correlation of pH between the mosses and the substratum on which they are attached; there is some correlation between the mosses and the deeper soil, but not so close as with the former.
8. Moisture supply is an important factor in moss growth even when the H-ion concentration is suitable.

9. Mosses in mixed groups have a similar pH adjustment.
10. There are some indications that the mosses in this region have followed in successions.
11. Soil tests conform to the usual type. Hilltops and upper flats are acid while lower slopes and bases are neutral to alkaline.
12. Mosses have adjusted themselves to these conditions rather closely. They seem to have the same general relations to their substratum, so far as H-ion concentration is concerned, as the plants of the higher orders.

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